

## Essential Oils Widely Used in Flavors and Fragrances

*Essential oils and their derivatives are widely used as flavors and fragrances, a market estimated to be worth \$9 billion. In 1994, the United States exported essential oils valued at \$176.1 million, while importing \$206.7 million. U.S. production of peppermint and spearmint oils in 1994 were 7.4 and 2.2 million pounds, respectively. Supplies of orange oil and d-limonene, which are highly dependent upon orange juice production in Brazil and the United States, could continue to be tight into 1996.*

Essential oils, also called volatile or ethereal oils, refer to a large class of natural aromatic substances found in various flowers, leaves, seeds, roots, bark, wood, resin, and the rinds of some fruits. These substances resemble oils in appearance, but they are generally light, non-greasy, and highly volatile—meaning they evaporate readily. Essential oils, therefore, are chemically distinct from, and should not be confused with, fatty oils.

Essential oils are typically named after the plants from which they are derived—for example, peppermint oil and orange oil—and are called “essential” because they tend to represent the natural “essence” of the plant based on various characteristics such as odor and taste. Essential oils and their derivatives are widely used as flavors and fragrances, and some are used for their chemical or biological activity.

Essential oils are used in a wide variety of products including foods, beverages, cosmetics, pharmaceuticals, bug repellents, solvents, and more. In some cases, the oil itself may be the final product sold to consumers. It is hard to determine how many oils are commercially traded, but nearly 70 are listed in the *CTFA Cosmetic Ingredient Handbook (1)*, and it is likely many more are sold in markets throughout the world. Production figures for most essential oils are hard to come by, but Brian M. Lawrence, a noted authority on essential oils, has estimated the world's top 20 oils by volume (table 15).

### **Essential Oils Face Growing Markets and Stiff Competition**

Essential oils are an important component of the worldwide flavors and fragrances markets, now estimated to be worth nearly \$9 billion (2). One recent study done by the Business Communications Company estimates that sales of chemicals used in finished cosmetic and toiletry products will reach \$3.7 billion by 1998. Essential oils are the largest and most expensive chemical ingredients used to make these products (3). Two factors that are likely driving demand upward are: the “green revolution” and improving standards of living in many developing economies. The “green revolution” has many consumers in developed countries increasingly interested in products with natural ingredients, while rising standards of living and increased international trade are opening new markets for many personal-care products.

While strong worldwide flavor and fragrance markets continue to provide outlets for essential oils, market competition

remains tight for many oils. While most users of essential oils are companies in Europe, the United States, and Japan, essential oil production occurs throughout the world. Though the United States is a large consumer of essential oils, U.S. production of major essential oils is limited mainly to byproducts of the citrus, wood, and pulping industries. Peppermint and spearmint are the only major oils that are produced as primary products from crops grown in the United States.

High costs of production and stiff competition from existing producers are major barriers to market entry. Production requires large amounts of raw material to yield significant quantities of oil and often requires large capital investments to process, extract, and store the oil. In addition, a new producer will often face fierce price competition from existing producers, both foreign and domestic. Some foreign countries even have special government-subsidized programs designed to promote the essential-oil industry by helping to absorb certain costs. Also, most essential oils have established buyer-seller relationships. Buyers and users of essential oils

Table 15—Essential oils: Estimated world production and value, top 20 oils

Essential oil	Volume Tons	Value \$1,000
Orange	26,000	58,500
Cornmint	4,300	34,400
Eucalyptus, cineole-type	3,728	29,800
Citronella	2,830	10,800
Peppermint	2,367	28,400
Lemon	2,158	21,600
Eucalyptus, citronellal-type	2,092	7,300
Clove leaf	1,915	7,700
Cedarwood (U.S.)	1,640	9,800
Litsea cubeba	1,005	17,100
Sassafras (Brazil)	1,000	4,000
Lime, distilled (Brazil)	973	7,300
Native spearmint	851	17,000
Cedarwood (Chinese)	800	3,200
Lavandin	768	6,100
Sassafras (Chinese)	750	3,000
Camphor	725	3,600
Coriander	710	49,700
Grapefruit	694	13,900
Patchouli	563	6,800

Source: Brian M. Lawrence, “A Planning Scheme to Evaluate New Aromatic Plants for the Flavor and Fragrance Industries,” *New Crops: Exploration, Research, and Commercialization*, Jules Janick and James E. Simon, Editors, John Wiley and Sons, Inc., New York, NY, 1993, p. 620.

often have product formulas that are dependent on certain oil qualities and characteristics. Buyers, therefore, look for producers who can supply consistent and sufficient quantities of quality oils, and are reluctant to change.

### Extraction Methods Vary

Chemically, essential oils are mostly tropanes, poly-isoprenoid units, aromatics, heterocyclics, and terpenes. The oils are generally located in specialized glands or cells of the plant, and can be extracted from plant material using various methods including direct steam distillation, water distillation, water and steam distillation, solvent extraction, and mechanical pressing. Other specialty methods of essential oil extraction may be used to produce some exotic and often more expensive oils. The specific method used depends upon the plant material and the desired characteristics of the end product.

Direct steam distillation or water and steam distillation are the most common extraction methods for most high-volume essential oils, such as the mint oils, eucalyptus oils, citronella, cedarwood, distilled lime, coriander, and patchouli. Prior to distillation, the plant material is often field cured, dried, and/or partially disintegrated in order to expose as many oil glands as possible to the steam. In a basic steam distillation unit, steam releases the volatile oil from the plant material, and the steam and oil then pass through a cold-water condenser to a collection container, where the volatile oil will float on top of the water and can be removed.

Most citrus oils, except distilled lime, are recovered from the fruit rinds by mechanical expression, and are largely a byproduct of the juice industry. Depending on the type of equipment, oil extraction can take place before, during, or after juice extraction. The basic cold-pressed, oil-recovery process involves rupturing (by mechanically pressing) the balloon-shaped oil glands of the peel in water. The resulting mixture is strained to remove large particles of peel and other debris, and then is centrifuged to separate the oil and water.

Solvent extraction is often used for more delicate plant materials such as flower petals, where high-temperature steam distillation would alter the chemical composition of the essential oil. The solvent chemically extracts the essential oil from the plant material, and then the solvent and the oil are separated. Various solvents can be used, but if the product is destined for human consumption in some form, alcohol (methyl or ethyl) is usually used because of possible solvent residue.

### Foreign Trade Up in 1994

U.S. essential oil trade was at record-high levels for both imports and exports in 1994 (tables 16 and 17). The United States exported a total of 12.3 million kilograms of essential oils valued at \$176.1 million, while importing 25.4 million kilograms worth \$206.7 million. Record exports were largely attributed to gains in peppermint, spearmint, and orange oils. Record imports were due mostly to an increase in orange oil.

Mint and citrus oils (including bergamot) continue to be the most important export oils for the United States, accounting for 55 and 27 percent, respectively, of the total essential-oil export value in 1994. Major foreign markets for U.S. mint oils include the United Kingdom, Japan, and France, while major markets for U.S. citrus oils include the United Kingdom, Japan, and Canada. Citrus oils were also a significant portion of U.S. essential oil imports, accounting for 33 percent of total import value. Major foreign suppliers are Brazil, Argentina, Mexico, and Italy.

### Citrus Oil Supply Dependent on Juice Production

Citrus oils are likely the most widely used essential oils in the world, with four of them—orange, lemon, lime, and grapefruit—ranking in the top 20 in volume. Most citrus oils, particularly bergamot and orange, are used as fragrance components in many cosmetic and personal-care products, such as soaps, detergents, creams, lotions, and perfumes. Orange,

Table 16—U.S. essential oil imports, volume and value, selected oils, 1992-94

Essential oil	1992		1993		1994	
	Volume Kilograms	Value \$1,000	Volume Kilograms	Value \$1,000	Volume Kilograms	Value \$1,000
Peppermint	40,704	654.5	146,739	2,558.1	305,417	5,622.7
Spearmint	240,265	3,171.7	318,487	3,019.5	426,144	5,184.6
Other mint	116,015	817.6	79,498	859.6	76,858	834.9
Bergamot	42,362	3,782.5	37,821	2,362.9	37,970	1,607.6
Grapefruit	205,981	1,162.5	178,501	1,331.4	272,261	2,599.8
Lemon	1,721,645	27,898.3	1,406,479	23,028.6	1,368,513	22,918.8
Lime	1,037,955	14,406.8	756,724	13,267.9	864,563	15,175.0
Orange	9,989,360	12,272.1	11,908,627	16,205.6	14,880,881	23,525.6
Other citrus	231,612	2,430.6	358,230	2,866.6	205,115	2,863.3
Cassia	445,091	15,117.3	285,158	16,477.1	473,738	17,571.4
Cedarwood	365,855	1,276.1	338,179	1,693.6	557,895	2,977.5
Citronella	567,597	2,267.1	885,843	3,955.2	626,107	4,767.6
Geranium	53,074	1,969.5	64,251	2,924.9	82,707	4,710.2
Lavender	484,628	6,914.0	417,518	6,253.5	339,621	4,982.8
Patchouli	246,352	4,064.6	390,100	7,398.6	454,918	8,999.7
Rose	3,140	7,519.1	2,504	6,666.0	5,443	6,713.6
Sandalwood	28,716	3,152.8	31,052	3,280.9	26,398	3,669.9
Other essential oils	3,835,030	77,809.3	4,322,144	73,471.2	4,432,021	72,024.0
<b>Total</b>	<b>19,655,382</b>	<b>186,686.4</b>	<b>21,927,855</b>	<b>187,621.2</b>	<b>25,436,570</b>	<b>206,749.0</b>

Source: U.S. Department of Commerce, Bureau of the Census.

Table 17--U.S. essential oil exports, volume and value, selected oils, 1992-94

Essential oil	1992		1993		1994	
	Volume Kilograms	Value \$1,000	Volume Kilograms	Value \$1,000	Volume Kilograms	Value \$1,000
Peppermint	1,568,728	52,613.3	1,655,168	53,278.9	2,115,696	66,925.3
Spearmint	644,246	21,254.9	700,752	22,601.6	739,792	24,207.0
Other mint	308,393	7,640.8	164,177	4,236.0	228,689	5,307.3
Bergamot	185,331	2,914.3	180,162	3,540.0	112,176	1,907.2
Lemon	868,772	10,526.7	841,422	11,834.4	818,210	11,928.2
Lime	231,407	5,052.3	196,528	4,057.5	282,917	4,607.7
Orange	3,407,916	10,195.5	3,665,228	11,965.2	4,207,009	17,142.6
Other citrus	647,530	6,272.7	727,524	10,083.0	906,093	12,532.5
Cedarwood, Clove, and Nutmeg	649,976	5,236.7	823,367	5,347.4	883,910	4,736.2
Geranium	58,786	1,565.9	18,130	671.2	39,450	977.4
Jasmine	22,813	62.4	8,603	135.2	4,739	152.5
Lavender	76,481	1,431.7	59,983	1,358.3	73,944	1,712.6
Vetiver	15,933	434.8	10,507	431.7	12,570	503.3
Other essential oils	1,546,812	21,700.7	2,164,095	24,829.8	1,899,838	23,503.4
<b>Total</b>	<b>10,233,124</b>	<b>146,902.7</b>	<b>11,215,646</b>	<b>154,370.2</b>	<b>12,325,033</b>	<b>176,143.2</b>

Source: U.S. Department of Commerce, Bureau of the Census.

lemon, lime, grapefruit, and to a lesser extent bergamot, are also used extensively as flavoring agents in many food products, including alcoholic and nonalcoholic beverages, frozen dairy products, candy, baked goods, gelatins and puddings, meat and meat products, and others.

In large part, the current market situation for orange oil is very dependant on juice production and markets in major producing countries, such as Brazil and the United States. Large orange juice production often translates into large oil production. Last year's drought in Brazil resulted in lower quantities of oil available from Brazil, and has led to increased prices for both U.S. and Brazilian oils.

Since the beginning of the 1994 processing crop in Brazil, spot prices for California orange oil have doubled, while Florida and Brazilian oils have more than tripled (table 52). Early indications are for a strong orange crop in Brazil this year, but early juice output forecasts are down 9 percent from last year due to expected lower juice yields and increased domestic demand for fresh oranges. In addition, last year's drought delayed bloom and fruit set for the 1995 crop, and full-scale processing did not get underway until August. U.S. juice production will not be in full swing until December 1995. If supplies of juice from Brazil are indeed lower, it could be an indication of even higher orange oil prices to come.

### **D-limonene Used for Adhesives**

Most citrus essential oils are high in terpene content, and particularly the monoterpene hydrocarbon d-limonene, which accounts for 90 percent or more of the constituents in orange and grapefruit oils. These terpenes often are removed or reduced in order to inhibit spoilage, with the resulting oils used specifically as flavoring agents. The terpenes themselves are often a valuable commodity, and much orange oil is produced for its d-limonene content. Total production estimates for d-limonene are not available, but 19.5 million pounds were produced in Florida in 1993/94 (table 18).

Table 18--Florida d-limonene production, 1970/71-1993/94

Year	Production Pounds
1970/71	8,019,654
1971/72	9,456,725
1972/73	23,833,544
1973/74	21,216,553
1974/75	24,165,034
1975/76	18,472,531
1976/77	19,225,002
1977/78	17,091,624
1978/79	17,341,935
1979/80	19,629,004
1980/81	16,720,845
1981/82	13,519,036
1982/83	13,927,503
1983/84	13,721,626
1984/85	11,130,493
1985/86	12,107,458
1986/87	13,482,525
1987/88	14,563,104
1988/89	19,131,638
1989/90	15,138,111
1990/91	15,489,732
1991/92	14,493,036
1992/93	19,830,922
1993/94	19,548,481

Source: Florida Citrus Processors Association.

The largest market for both l- and d-limonene is in the production of tackifying resins for the adhesive industry, taking as much as 65 percent of limonene produced. The letters l and d are indicators of the optical activity of the limonene. For commercial use, the optical activity is of no significance except when specific taste and odor are an important factor. In this regard, it is d-limonene that must be used (along with other chemicals) to synthetically produce l-carvone, an important flavoring agent found naturally in spearmint oil. Pro-

duction of l-carvone consumes about 3 million pounds of d-limonene per year.

As with tackifying resins, optical activity is not important for the other major uses of limonene—as a solvent to replace petroleum distillates and chlorofluorocarbons (CFC's), and as an odorant for petroleum-derived solvents. With its pleasant odor and its perceived safety, limonene has found a place in many specialty cleaning products. Currently, these specialty markets account for about 25 to 30 percent of limonene consumption (4). Future use of d-limonene remains to be seen, but all terpenes may become increasingly important when the manufacture of CFC's and chlorinated solvents becomes illegal in the United States and 42 other countries in January 1996.

With last year's Brazilian drought and decreased quantities of orange oil, there has been a shortage of d-limonene, resulting in price increases of over 300 percent from last September (table 50). This shortage will likely continue until the Brazilian orange crop is processed. If Brazilian processing is low, d-limonene supplies could remain tight, with high prices for the remainder of the year. U.S. production will not begin until about December 1995, just as CFC phaseouts become mandatory. Many companies are already beginning to look for alternatives to CFC's, but the increasing demand and high prices for d-limonene may force some users to look for other, lower cost alternatives, such as other terpenes and synthetic

cleaners. However, if supply is good and prices can be lowered when the CFC phaseout begins, d-limonene could have excellent market opportunities.

### U.S. Mint Industry Centered in the West

Mint oils are among the most widely used essential oils in the world. The three main varieties of mint grown for commercial use are peppermint, spearmint, and cornmint (also called Japanese mint). Each oil is unique in its general chemical composition, and, therefore, has certain specialized uses. Both spearmint and peppermint oils are used extensively as flavoring agents in chewing gums, candies, beverages, ice creams, baked goods, oral hygiene products, and various pharmaceutical preparations. Spearmint is typically milder in flavor and fragrance, and is perhaps more widely used in products that require a milder taste or odor. Peppermint oil tends to have more antiseptic and local anesthetic qualities and, consequently, is more widely used in cold, cough, and other medicinal preparations. Cornmint oil has a very high menthol content, and is produced primarily for menthol production. Both menthol and peppermint oil are used to flavor tobacco.

Limited information on mint-oil marketing makes it difficult to assess the exact utilization of U.S. oils by various industries. However, it is likely that the traditional mint-oil products such as gums, candies, toothpastes, and mouthwashes likely account for the largest quantities of both peppermint and spearmint.

Table 19—U.S. peppermint oil: Supply, use, and price, 1970-94

Year	Supply			Utilization		Season-avg price	
	Production 1/	Imports 2/	Total	Exports 2/	Total	Current dollars 1/	Constant 1987 dollars 3/
--1,000 pounds--							
\$/pound							
1970	5,007	5.0	5,012	1,951.0	3,061	3.68	10.48
1971	3,746	16.0	3,762	2,540.0	1,222	4.10	11.08
1972	3,004	8.0	3,012	2,227.0	785	5.25	13.49
1973	3,173	4.0	3,177	2,409.0	768	7.89	19.10
1974	3,302	7.0	3,309	2,197.0	1,112	13.80	30.73
1975	3,753	9.0	3,762	1,603.0	2,159	12.60	25.61
1976	3,700	33.0	3,733	2,194.0	1,539	14.80	28.30
1977	4,409	18.0	4,427	2,023.0	2,404	14.30	25.58
1978	5,557	6.6	5,564	2,506.7	3,057	10.60	17.58
1979	4,713	6.6	4,720	2,755.8	1,964	9.91	15.11
1980	4,611	11.0	4,622	2,206.8	2,415	9.40	13.11
1981	4,191	6.6	4,198	2,085.6	2,112	9.39	11.90
1982	3,668	6.6	3,675	2,389.8	1,285	9.24	11.03
1983	3,867	15.4	3,882	2,169.3	1,713	10.10	11.58
1984	4,334	6.6	4,341	1,880.5	2,460	10.80	11.87
1985	4,317	8.8	4,326	1,869.5	2,456	10.20	10.81
1986	4,328	101.4	4,429	2,356.7	2,073	10.70	11.04
1987	4,495	158.7	4,654	2,658.8	1,995	11.70	11.70
1988	5,360	37.5	5,397	2,709.5	2,688	15.90	15.30
1989	6,652	15.4	6,667	3,313.5	3,354	13.10	12.07
1990	6,953	34.2	6,987	3,495.7	3,492	13.90	12.27
1991	6,561	55.8	6,617	3,695.9	2,921	13.30	11.31
1992	7,383	89.7	7,473	3,458.4	4,014	12.80	10.59
1993	6,027	323.5	6,351	3,649.0	2,701	13.30	10.77
1994	7,434	673.3	8,107	4,664.3	3,443	14.60	11.56

1/ Source: USDA, National Agricultural Statistics Service. 2/ Source: U.S. Department of Commerce, Bureau of the Census. 3/ Deflated by the GDP implicit price deflator.

Table 20—U.S. spearmint oil: Supply, use, and price, 1970-94

Year	Supply			Utilization		Season-avg price	
	Production 1/	Imports 2/	Total	Exports 2/	Total	Current dollars 1/	Constant 1987 dollars 3/
	--1,000 pounds--					\$/pound	
1970	2,126	--	2,126	632.0	1,494	4.64	13.22
1971	2,008	--	2,008	838.0	1,170	4.18	11.30
1972	1,511	--	1,511	842.0	669	5.14	13.21
1973	1,348	--	1,348	1,101.0	247	8.22	19.90
1974	1,455	--	1,455	982.0	473	10.70	23.83
1975	1,778	--	1,778	861.0	917	10.40	21.14
1976	1,686	--	1,686	1,167.0	519	12.30	23.52
1977	2,329	--	2,329	996.0	1,333	12.40	22.18
1978	3,244	0.0	3,244	1,040.6	2,203	7.46	12.37
1979	1,921	4.4	1,925	1,353.6	572	8.72	13.29
1980	2,139	17.6	2,157	1,183.9	973	9.61	13.40
1981	2,177	61.7	2,239	1,029.6	1,209	9.42	11.94
1982	1,355	105.8	1,461	901.7	559	12.60	15.04
1983	1,596	55.1	1,651	749.6	902	12.30	14.11
1984	2,019	163.1	2,182	857.6	1,325	12.60	13.85
1985	2,317	26.5	2,343	809.1	1,534	11.70	12.39
1986	2,658	24.3	2,682	910.5	1,772	11.40	11.76
1987	2,060	180.8	2,241	822.3	1,418	12.10	12.10
1988	1,745	152.1	1,897	985.5	912	12.80	12.32
1989	1,846	134.5	1,980	1,393.3	587	13.90	12.81
1990	2,565	327.8	2,893	1,446.6	1,446	14.90	13.15
1991	3,108	410.4	3,518	1,492.3	2,026	13.90	11.82
1992	3,640	529.7	4,170	1,420.3	2,749	12.80	10.59
1993	2,722	702.1	3,424	1,544.9	1,879	12.30	9.96
1994	2,213	939.5	3,152	1,631.0	1,522	12.30	9.74

-- = Not available.

1/ Source: USDA, National Agricultural Statistics Service. 2/ Source: U.S. Department of Commerce, Bureau of the Census. 3/ Deflated by the GDP implicit price deflator.

mint oils produced in the United States. Mint oils, particularly spearmint, also are used in various cosmetic and toiletry products. Growth in natural ingredients in these areas could mean expanded usage of mint oils as fragrances. In addition, exports traditionally have accounted for a large portion of U.S. mint oil production. During the 1990's, exports of U.S. peppermint and spearmint oil equaled 55 and 53 percent of production, respectively. Changes in U.S. mint oil production, particularly peppermint, may be highly dependent on growth in export markets.

In the United States, the mint industry is relatively small compared with most other agricultural commodity sectors. There are only about a half dozen major buyers of peppermint and spearmint oils. These buyers purchase much of the oil produced in the United States, and often contract for acreage and price prior to the growing season. Buyers are often the flavor formulators for end users, and may contract with a certain end user, such as a chewing gum manufacturer, to provide the gum company with a certain blend of oils for their product.

Because end-product manufacturers want a consistent tasting product, either they or their formula makers (buyers) seek consistent quality oils that can provide certain flavors. This often means a buyer is likely to purchase oil from certain growers that have a history of producing consistent-quality

oils, despite slight changes in price. Because mint oils, like most essential oils, are very potent and usually require only small amounts in end products to produce the desired effects, the price of the oil is generally not a major component of the price of end products. For example, one pound of mint oil will flavor nearly 45,000 sticks of gum. For this reason, small to moderate changes in the price of mint oils often does not effect the purchase of these oils.

The United States is the largest producer of peppermint and spearmint oils in the world. In 1994, U.S. peppermint production was 7.4 million pounds, and spearmint production was 2.2 million pounds (tables 19 and 20). Over time, production of both peppermint and spearmint oils has shifted westward, with the Far Western States—primarily Idaho, Oregon, and Washington—accounting for 87 and 78 percent, respectively, of total U.S. production.

Spearmint oil production in the Far West has a marketing order, which has been in place since 1980. The order is a volume-control program that regulates the marketing of oil through annual sales allotments. The overall goal is to control grower stocks of oils in order to create more stable grower prices from year to year. There is no marketing order for peppermint. [Charles Plummer, (202) 219-0717]

1. *CTFA Cosmetic Ingredient Handbook*. The Cosmetic, Toiletry, and Fragrance Association, Inc., Washington, DC, 1992.
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3. "Chemicals in Cosmetics and Toiletries See Modest Growth." *Chemical Marketing Reporter*. Schnell Publishing Company, New York, NY, Vol. 244, No. 10, September 6, 1993, p. 29.
4. McBride, Joseph J. "Limonene—A Versatile Chemical." *1993 Citrus Engineering Conference*, Vol. XXXIX. Florida Section of American Society of Mechanical Engineers, Lakeland, FL, 1993.